Riverside Technology, inc.

MEMORANDUM

TO: Janice Sylvestre
FROM: Mark Woodbury
DATE: 30 April 2004
SUBJECT: South Platte Streamflow Regulation Modeling Strategies

Background

As part of its plan to provide an Advanced Hydrologic Prediction Service (AHPS), the National Weather Service (NWS) is using the NWS River Forecast System (NWSRFS) to prepare long-range probabilistic forecasts of streamflow. The presence of extensive systems of streamflow regulation to capture and re-regulate or divert runoff in many parts of the country require additional data, effort, and new procedures to characterize and accurately predict the effect of this regulation for developing forecasts.

As an initial step in developing national implementation strategies, a document titled "*Streamflow Regulation Issues and Solutions Identification"* (*Issues Identification*) was distributed to each RFC. The document included a request for feedback and responses were received from every RFC. RTi prepared a memo dated 22 March, 2004 summarizing feedback from the RFCs. Another memo titled "General Streamflow Regulation Modeling Strategies" (*General Strategies)* is being prepared concurrently with this memo and presents initial thoughts on a general implementation approach for streamflow regulation accounting together with modeling strategies to guide future development and implementation activities and efforts. The implementation approach outlines a sequence of steps to be taken in assessing regulation in the basin, gathering data, analyzing the data and identifying patterns, formulating and testing a modeling approach, and implementing the regulation modeling.

This memo specifically addresses modeling strategies for the South Platte basin in the Missouri Basin RFC (MBRFC). The modeling strategies that are presented identify specific modeling tools and techniques that could be applied to some of the specific regulation issues found in the South Platte Basin. The list is not comprehensive nor does it define the specific application for the strategies identified. An implementation plan will be prepared in consultation with MBRFC in which more detail will be provided in defining approaches to be taken for specific parts of the basin. As an initial step in preparation of the implementation plan, RTi has compiled information on the South Platte basin following the format of the implementation approach outlined in the *General Strategies* memo. That compilation is included as an appendix to this memo.

Specific Strategies

Following are some strategies that can be applied specifically in the South Platte basin to represent some of the issues that have been identified to date.

Pre-calculation of local flows – Many of the regulation operations at upstream reservoirs and diversions depend on water availability at downstream communities and agricultural areas. Although the normal sequence of NWSRFS operations is to proceed sequentially from upstream to downstream, rules for operating upstream controls within a reservoir operation will require evaluation of time series states at downstream locations. This will require that local inflow time series be pre-computed so that they can be used for evaluation and simulation of decision making at upstream locations. In some cases local or unregulated flow time series may be combined and routed to downstream locations in various

combinations in order to provide input time series to a network model (RES-J) which will compute releases and diversions that can ultimately be used to finalize the total flow computations in each segment. While this may be disruptive to the forecast process, it may be essential to regulation accounting. This strategy is likely to be a prerequisite for many of the strategies that follow.

Composite Reservoir – In at least one segment there are several small to medium sized reservoirs whose primary purpose is water supply during drought. As such, these reservoirs are generally kept full except when water is needed during drought periods. In these and similar instances it may be possible to use a composite reservoir to represent the total reservoir storage capacity in the segment. Some estimate of the drainage area of the segment compared to the area controlled by the reservoirs could be made to allocate the percentage of the total runoff to reservoir inflow, with the remainder appearing as outflow from the segment. Once full, the reservoirs simply pass any inflow. Since the reservoirs do not all reach a full condition at the same time, a curve would be developed representing the composite outflow as a function of composite storage. This curve would be calibrated based on historical data. Drought releases could be specified using a minimum release from the composite reservoir, based on current unregulated flow. This approach has the benefit of representing the behavior of the basin without further subdividing the segment and modeling many reservoirs where real-time data may not be available and whose individual contribution is minimal but whose composite effect is significant.

Inter-basin diversions – Some inter-basin diversions occur between segments and between forecast groups within MBRFC. The TATUM routing model can be used to divide the flow into layers that have different routing parameters that effectively divide and redirect the flow. For example, we could use the TATUM operation to model a diversion where all flows from 0 – 200 cfs remain in the channel, 50% of the flow from 200 – 400 cfs is diverted to another basin, and the remaining flow above 400 cfs remains in the channel. The LOOKUP3 operation could be used to estimate an inter-basin diversion based on availability in one basin and deficit in the other using pre-computed local flows on each side.

Riparian Groundwater Pumping – In the lower part of the South Platte basin there is pumping from the groundwater aquifer adjacent to the river that has a direct impact on streamflow. With some analysis and trial and error modeling, this situation might be represented using RES-J to model a reservoir in which inflow is the simulated inflow to the reach, withdrawals represent that part of the pumping that is used consumptively, and outflow is a function of total reservoir storage and represents outflow from the reach. The outflow storage curve would actually be represented by the combination of the storage elevation and elevation discharge curves, which would be calibrated based on historical data.

Multiple small diversions – Where multiple small diversions are taken for irrigation in a sub-basin these may be aggregated into a single diversion whose demand could be computed from the CONS_USE operation, the CHANLOSS operation, a LOOKUP or LOOKUP3 operation, or a combination of these and other time series manipulation operations.

Large diversions – Larger diversions within a segment may need to be handled separately from the aggregated small diversions. Where the large diversion directs flow to another basin and return flows occur there, this could be accounted for using the consumptive use model and its associated return flow.

Major Reservoirs – The RES-J or RES-SNGL operations can be used to model the major reservoirs in the basin. USACE reservoirs can be modeled using typical model features for flood regulation. The major water supply reservoirs will need to be coupled with some method for computing downstream demand.

Water Rights – The use of the water in the South Platte basin is dictated by a complex system of water rights. To some extent these can be represented by the demand associated with consumptive use based on irrigated acres and cropping patterns in the region. The CONS_USE operation will be applied as much as

possible in these cases. In other cases, however, major diversions can vary significantly, and water rights calls can be issued that initiate a reservoir release that passes multiple forecast points before it is withdrawn by the water right holder. These situations may be very difficult to model and it is not clear to what extent overall demand and availability can be relied upon as a substitute for detailed water rights modeling.

Basic NWSRFS modeling tools – Most of the NWSRFS operations noted in *General Strategies* are likely to find application in the modeling approach to streamflow regulation in the South Platte. The proposed enhancements to the CONS_USE model would be particularly useful in the South Platte implementation. The proposed RES-J enhancements also would provide added flexibility to simulate the complex relationships found in the basin.